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PATENT & TRADEMARK OFFICE

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appellant : Charles P. McShane et al. Art Unit : 1751
Serial No. : 09/288,877 Examiner : Ogden, N.
Filed : April 9, 1999
Title : VEGETABLE OIL BASED DIELECTRIC FLUID AND METHODS OF USING SAME

BOARD OF PATENT APPEALS AND INTERFERENCES
Commissioner for Patents
Washington, D.C. 20231

BRIEF ON APPEAL

In response to the Advisory Action dated December 19, 2000 in the above-referenced application, and pursuant to the Notice of Appeal filed on November 27, 2000, Applicants submit the following Brief on Appeal. The date for filing the Brief on Appeal is extended from January 27, 2001 to February 27, 2001 by the attached Petition for a One Month Extension of Time under 37 C.F.R. § 1.136(a) and the attached check for the $110.00 fee as required by 37 C.F.R. § 1.17(a)(1).

(1) Real Party in Interest

The real party in interest is Cooper Industries, P.O. Box 4446, Houston, Texas 77210.

(2) Related Appeals and Interferences

None.

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I hereby certify under 37 CFR §1.8(a) that this correspondence is being deposited with the United States Postal Service as first class mail with sufficient postage on the date indicated below and is addressed to the Commissioner for Patents, Washington, D.C. 20231.

February 27, 2001
Date of Deposit

Judith Witzel
Signature

Judith A. Witzel
Typed or Printed Name of Person Signing Certificate

(3) Status of Claims

The present application as filed included 38 claims. Claims 39-41 were added in the amendment and response filed May 1, 2000. The current status of the claims is as follows:

Claims 1-14, 21 and 35-37 are canceled.

Claims 15-20, 22-34 and 38-41 are pending.

Claims 15-20, 22-34 and 38-41 stand rejected.

(4) Status of Amendments

As noted in Section 2 of the Advisory Action dated December 19, 2000, the amendments proposed in the response filed November 27, 2000 will be entered upon the filing of this appeal.

(5) Summary of Invention

In view of the environmental problems caused by synthetic dielectric fluids used as coolants in electrical equipment, the present inventors recognized the need for a dielectric fluid that: (1) poses minimal environmental hazards; (2) degrades quickly and easily so that spills do not contaminate the soil or water table for any significant period of time; and (3) does not interfere in any significant way with natural biodegradation processes (Page 4, lines 5-8 of the specification). The inventors recognized that certain vegetable oils or mixtures of vegetable oils, when used as dielectric fluids, require little maintenance, meet or exceed applicable safety and performance standards, and are free of substantial environmental hazards (page 4, lines 14-19).

These vegetable oil dielectric fluid compositions are preferably food grade materials, which is defined on page 7, lines 5-7 as a material that does not include components that are toxic or otherwise biologically hazardous. If the dielectric fluid includes non-vegetable oil components, page 7, line 19 to page 8, line 1 provides that the amount and/or character of the non-vegetable oil component must be carefully selected to preserve the environmentally safe nature of the fluid. For this reason, any synthetic components that are toxic and/or would not be expected to naturally degrade in a reasonable amount of time would adversely affect the environmentally safe nature of the dielectric fluid composition, and would not be useful as components for the composition (Id.).

(6) Issues on Appeal

I. The Rejections Under 35 U.S.C. § 102(b)

1. Whether Appellant has established that introduction of the alkylmethacrylate polymer additives described in JP 61-260,503 would materially change the basic and novel characteristics of the dielectric composition of the invention. If so, the rejection of claims 15-23, 26, 28-29, 31 and 38 under 35 U.S.C. § 102(b) in view of JP 61-260,503 is improper and should be reversed.

2. Whether Appellant has established that introduction of the halogenated hydrocarbon additives described in U.S. Patent No. 4,806,276 to Maier and would materially change the basic and novel characteristics of the invention. If so, the rejection of claims 15-23, 28-31 and 38-41 under 35 U.S.C. § 102(b) in view of U.S. Patent No. 4,806,276 to Maier is improper and should be reversed.

3. Whether Appellant has established that the castor oils described in U.S. Patent No. 3,702,895 to deSio have viscosities that fall outside the scope of the present claims. If so, the rejection of claims 15-23, 28-31 and 38-41 under 35 U.S.C. § 102(b) in view of U.S. Patent No. 3,702,895 to deSio is improper and should be reversed.

4. Whether the Examiner has established that the Clark publication, "Insulating Material for Design and Engineering Practice," teaches the use of the claimed dielectric compositions in electrical apparatus. If the Examiner has failed to do so, the rejection of claims 15-23, 28-31 and 38-41 under 35 U.S.C. § 102(b) in view of the Clark publication is improper and should be reversed.

II. The Rejection Under 35 U.S.C. § 103(a)

1. Whether Appellant has established that introduction of the aromatic additives described in U.S. Patent No. 4,724,824 to Sato et al. would materially change the basic and novel characteristics of the dielectric composition of the invention. If so, the rejection of claims 15-31 and 38-41 under 35 U.S.C. § 103(a) in view of U.S. Patent No. 4,724,824 is improper and should be reversed.

(7) Grouping of Claims

The claims stand or fall together.

(8) Argument

I. The Specification Clearly Defines the Scope of the Transitional Phrase "Consisting Essentially Of"

The Board of Patent Appeals and Interferences has taken the position that the burden is on the Appellant to establish that subject matter in the prior art is excluded from the claims by the transitional phrase "consisting essentially of."[1] When used in a claim as a transitional phrase, it is well established that "consisting essentially of" limits the scope of the claim to the specified ingredients and those that do not *materially* affect the *basic* and *novel* characteristics of a composition.[2]

The patent applicant is entitled to provide his own definition for the terms used in its claims, including the meaning of transitional phrases like consisting essentially of.[3] By using the term consisting essentially of, the drafter signals that the invention necessarily includes the listed ingredients and is open to unlisted ingredients that do not materially affect the basic and novel properties of the invention.[4] To determine whether a specified ingredient would materially affect the basic and novel characteristics of the invention - whether the ingredient would be outside the scope of the claim - it is necessary and proper to look to the specification.[5] Under well-settled principles, the applicant is entitled to provide its own definition of the terms used in the claims, including the transition phrase consisting essentially of.[6]

The invention is a food grade vegetable oil dielectric fluid composition that provides adequate longevity and electrical properties when used as a coolant in an electrical apparatus. Food grade as used in the present specification means a material that does not include

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[1] Ex parte Hoffman, 12 USPQ2d (BNA) 1061, 1064 (Bd. Pat. App. 1989).
[2] In re Herz and Willis, 190 USPQ (BNA) 461, 463 (CCPA 1976) (emphasis in original).
[3] PPG Indus. Inc. v. Guardian Indus. Corp., 48 USPQ2d (BNA) 1351, 1355 (Fed. Cir. 1998).
[4] Ex parte Hoffman, 12 USPQ2d (BNA) at 1064.
[5] In re Herz and Willis, 190 USPQ (BNA) at 463; Ex parte Hoffman, 12 USPQ2d (BNA) at 1064.
[6] PPG Indus. v. Guardian Indus., 48 USPQ2d (BNA) at 1355.

components that are toxic or otherwise biologically hazardous (page 8, lines 5-7). If the dielectric fluid includes non-vegetable oil components, the amount and/or character of the non-vegetable oil component must be carefully selected to preserve the environmentally safe nature of the fluid (page 7, line 19 to page 8, line 1). For this reason, any synthetic components that are toxic and/or would not be expected to naturally degrade in a reasonable amount of time would adversely affect the environmentally safe nature of the dielectric fluid composition, and would not be useful as components for the composition (Id.).

In view of the above, the present specification makes clear that if a potential ingredient is toxic or otherwise biologically hazardous (non-biodegradable), the potential ingredient would alter the basic and novel characteristic of the present dielectric composition – its food grade character. The present specification makes clear that a material change of fundamental character would be a change from a food grade material to a non-food grade material. To determine whether a potential additive is excluded from the scope of the claims, the question is whether addition of the additive would alter the food grade character of the composition.

II. The Alkylmethacrylates Described in JP 61-260,503 Would Alter the Food Grade Character of the Dielectric Composition

The cited JP '503 abstract describes a dielectric composition that includes a vegetable oil and an alkylmethacrylate polymer at a concentration of up to 5% by weight as a reliability enhancer. The acrylic resins are well known to be volatile, synthetic compounds that are highly toxic.[7] For this reason, acrylic resins like alkylmethacrylates would alter the food grade character of the dielectric fluid of the invention. Therefore, Appellants respectfully submit that introduction of alkylmethacrylates would materially change the characteristics of the presently claimed dielectric fluid composition from food grade to non-food grade. For this reason, the alkylmethacrylates are excluded by the recitation of consisting essentially of in the present claims, as well as by the characterization of the dielectric fluid of the composition as a food grade material.

[7] For example, Hawley's Chemical Dictionary, R. Lewis, ed., (1997) describes acrylic acid as irritating and corrosive to skin, toxic by inhalation, and explosively polymerizable (See Tab 1).

The JP '503 abstract fails to teach or suggest such a food grade dielectric fluid. In addition, based on the teachings of the JP '503 abstract, one of ordinary skill in the art would not be led to modify a vegetable oil composition to eliminate the polymeric reliability enhancer. For these reasons, Appellants respectfully submit that the presently claimed invention is neither anticipated under 35 U.S.C. § 102(b) nor obvious under 35 U.S.C. § 103(a) in view of the JP '503 abstract. Appellants respectfully request that the Board of Patent Appeals and Interferences reverse this rejection.

III. The Halogenated Hydrocarbon Additives in U.S. Patent No. 4,806,276 Would Alter the Good Grade Character of the Dielectric Composition

The Maier '276 reference proposes using halogenated hydrocarbons and surfactant additives in dielectric oils to enhance their longevity. The halogenated compounds are well known to be toxic and environmentally unsafe,[8] and, if used as an additive in the dielectric fluid of the invention, would be expected to alter its food grade character. Therefore, Appellants respectfully submit that introduction of halogenated hydrocarbons would materially change the characteristics of the presently claimed dielectric fluid composition from food grade to non-food grade. For this reason, the halogenated hydrocarbons are excluded by the recitation of consisting essentially of in the present claims, as well as by the characterization of the dielectric fluid of the composition as a food grade material.

In addition, the cited Maier '276 reference fails to teach or suggest that a vegetable oil composition without these potentially toxic additives would be suitable for long-term use in an electrical device. Based on the teachings of Maier '276, one of ordinary skill in the art would not be led to modify a vegetable oil composition to eliminate these halogenated hydrocarbon additives.

For these reasons, Appellants respectfully submit that the presently claimed invention is neither anticipated under 35 U.S.C. § 102(b) nor obvious under 35 U.S.C. § 103(a) in view of

[8] For example, Hawley's Chemical Dictionary, R. Lewis, ed., (1997) describes halogenated hydrocarbons as toxic and explosive. (See Tab 2).

the Maier '276 reference. Appellants respectfully request that the Board of Patent Appeals and Interferences reverse this rejection.

IV. The Viscosity of the Castor Oils Described in U.S. Patent No. 3,702,895 to deSio Fall Outside the Scope of the Claims

The de Sio '895 reference teaches that any flowable dielectric, such as vegetable, mineral or other organic liquids, would be suitable for use in an electrical device (See col. 6, lines 9-12 of the '895 patent.). This reference teaches that castor oil would be a suitable dielectric fluid. However, the viscosity of castor oil renders the material unsuitable for use in many electrical devices, such as transformers. Castor oil is thick and unflowable within the operating temperature range required for transformer operation, and does not exhibit the proper convective cooling properties required for effective transfer of heat in such an application.

With respect to the viscosity of castor oil, Appellants attach information from the CRC Handbook of Chemistry and Physics, 59^{th} edition, 1978-79, which states that castor oil has an absolute viscosity of about 231 cp at 40 °C and 16.9 cp at 100 °C.[9] Since castor oil has a density of about 0.97 grams per cm^3, this material would have a kinematic viscosity of about 238 cSt at 40 °C and about 17.4 cSt at 100 °C, which are clearly outside the ranges in the present claims.

The dielectric fluid of the invention has a viscosity between about 2 and about 15 cSt at 100 °C, and less than about 110 cSt at 40°C, which ensures that the fluid has sufficient coolant properties for use in transformer applications. The deSio '895 reference fails to teach or suggest this viscosity range, and fails to recognize or appreciate the advantages of using materials with these properties in electrical applications. For these reasons, Appellants respectfully submit that the present invention is neither anticipated by nor obvious in view of diSio '895. Appellants respectfully request that the Board of Patent Appeals and Interferences reverse this rejection.

[9] See Tab 3.

V. The Clark Publication Fails to Teach or Suggest the Use of the Claimed Dielectric Composition in an Electrical Apparatus

Page 132 of the Clark publication, "Insulating Material for Design and Engineering Practice," mentions in passing that vegetable oils may be used as insulating liquids in electrical applications. Page 210 of Clark states that castor oil has been used as an insulating and cooling liquid in transformers.[10] However, Clark teaches that the other vegetable oils have been used in electrical applications as plasticizers in synthetic resin compositions for coating electrical equipment. Page 211 of Clark states that vegetable oils with three double bonds tend to oxidize, which limits their use as a dielectric or cooling impregnant.

Clark teaches that castor oil would be useful as a dielectric coolant, but, as noted above, castor oil has a viscosity outside the ranges of the present claims. Moreover, this reference teaches that the preferred vegetable oils of the invention are subject to oxidation and therefore not suitable for use as dielectric or cooling materials in electrical equipment. So, one of ordinary skill in the art, after reading Clark's discussion in its entirety, would not be led to use vegetable oils (other than castor oil) as dielectric coolants in electrical applications, unless these materials were modified with environmentally incompatible performance-enhancing additives.

In view of the above, Appellants respectfully submit that the present claims are neither anticipated under 35 U.S.C. § 102(b) nor obvious under 35 U.S.C. § 103(a) over the Clark reference. The Board of Patent Appeals and Interferences is respectfully requested to reverse this rejection.

VI. The Aromatic Additives Described in U.S. Patent No. 4,724,824 to Sato et al Would Alter the Food Grade Character of the Dielectric Composition

The Sato '824 reference teaches that aromatic additives are required to provide a suitable vegetable oil dielectric fluid. The aromatics, which have ring structures related to benzene, are well known to be toxic and non-biodegradable,[11] and, if used as an additive in the dielectric fluid of the invention, would be expected to alter its food grade character. Therefore, Appellants

[10] See Section IV above.
[11] See Tab 4.

respectfully submit that introduction of an aromatic compound would materially change the characteristics of the presently claimed dielectric fluid composition from food grade to non-food grade. For this reason, the aromatic compounds are excluded by the recitation of consisting essentially of in the present claims, as well as by the characterization of the dielectric fluid of the composition as a food grade material.

The present invention provides a dielectric fluid that does not require aromatic additives to increase its stability. The Sato '824 reference fails to teach or suggest such a dielectric fluid. In addition, based on the teachings of the '824 patent, one of ordinary skill in the art would not be led to modify a vegetable oil composition to eliminate the aromatic compounds.

For these reasons, Appellants respectfully submit that the presently claimed invention is not obvious under 35 U.S.C. § 103(a) in view of the Sato '824 reference. Appellants respectfully request that the Board of Patent Appeals and Interferences reverse this rejection.

VII. Conclusion

For the reasons advanced above, Appellants respectfully submit that the present claims are allowable over the cited prior art references. Reversal of the rejections is respectfully requested.

Please apply any other charges or credits to Deposit Account No. 06-1050.

If questions remain regarding the above, please contact the undersigned.

Respectfully submitted,

Date: February 27, 2001

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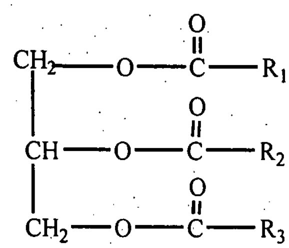
(9) Appendix – Claims on Appeal

15. A method of using an electrical device comprising employing in said device a dielectric fluid consisting essentially of at least one vegetable oil, wherein said vegetable oil is substantially free of chlorinated compounds and has a viscosity between 2 and 15 cSt at 100°C, and less than about 100 cSt at 40°C, and wherein said dielectric fluid is food grade.

16. The method of claim 15 wherein said vegetable oil comprises a triglyceride of the formula:



wherein R_1, R_2 and R_3 each, independently, is an alkyl or alkenyl group that may be straight-chained or branched, and may be unsubstituted or substituted.

17. The method of claim 15 wherein said vegetable oil comprises one or more fatty acid molecules that include at least one degree of unsaturation.

18. The method of claim 15 wherein said vegetable oil comprises one or more fatty acid molecules selected from the group consisting of: myristic, palmitic, stearic, oleic, linoleic, linolenic, arachidic, eicosenoic, behenic, erucic, palmitiolic, docosadienoic, lignoseric, tetracossenoic, margaric, margaroleic, gadoleic, caprylic, capric, lauric, pentadecanoic, and heptadecanoic acids.

19. The method of claim 15 wherein said vegetable oil has an open-cup fire point of greater than 300 °C.

20. The method of claim 15 wherein said vegetable oil has a specific heat of greater than about 0.3 cal/g°C.

22. The method of claim 15 wherein said dielectric fluid comprises a blend of two or more vegetable oils.

23. The method of claim 15 wherein said dielectric fluid comprises a blend of one or more vegetable oils and no more than about 30 percent by weight of a mineral oil.

24. The method of claim 15 wherein said dielectric fluid further comprises an antioxidant compound.

25. The method of claim 24 wherein said antioxidant compound is selected from the group consisting of: butylated hydroanisole, butylated hydrotoluene, tertiary butylhydroquinone, tetrahydrobutrophenone, ascorbyl palmitate, propyl gallate, and alpha-, beta- or delta-tocopherol.

26. The method of claim 15 wherein said dielectric fluid further comprises a pour point depressant.

27. The method of claim 15 wherein said dielectric fluid further comprises a dye or pigment.

28. The method of claim 15 wherein said device is an electrical transformer.

29. The method of claim 15 wherein said device is an electrical switchgear device.

30. The method of claim 15 wherein said device is an electrical transmission cable.

31. A device capable of generating or distributing electrical energy, wherein the device has incorporated therein a dielectric fluid consisting essentially of one or more

vegetable oils that are free of chlorinated compounds, wherein said vegetable oil has a viscosity between about 2 and 15 cSt at 100°C, and less than about 110 cSt at 40°C, and wherein the dielectric fluid is food grade.

32. The device of claim 31 further comprising an oxidation reducing composition enclosed in a housing composed of a polymeric material that is substantially permeable to oxygen, wherein the oxidation reducing composition is in contact with a headspace defined by the dielectric fluid.

33. The device of claim 32 wherein said oxidation reducing composition comprises one or more compounds selected from the group consisting of: sodium sulfite; copper sulfate pentahydrate; a combination of carbon and activated iron powder; mixtures of hydrosulfite, calcium hydroxide, sodium bicarbonate and activated carbon; a metal halide powder coated on the surface of a metal powder; sodium carbonate and sodium bicarbonate; and mixtures thereof.

34. The device of claim 32 wherein said oxidation reducing composition comprises iron oxide.

38. An electrical device comprising a tank for holding a dielectric fluid wherein said fluid consists essentially of one or more vegetable oils that are free of chlorinated compounds, wherein said vegetable oils have a viscosity between about 2 and about 15 cSt at 100°C, and less than about 110 cSt at 40°C, and wherein the dielectric fluid is food grade.

39. A method of using an electrical device comprising employing in said device a food grade dielectric fluid consisting essentially of at least one vegetable oil, wherein said vegetable oil is substantially free of chlorinated compounds.

40. A transformer having incorporated therein a food grade dielectric fluid consisting essentially of one or more vegetable oils that are free of chlorinated compounds.

41. A method for retrofilling an electrical device, comprising:

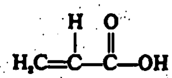
(a) removing an existing dielectric fluid from the device;

(b) drying the device; and

(c) replacing the existing dielectric fluid with a food grade dielectric fluid consisting essentially of one or more vegetable oils that are free of chlorinated compounds, wherein said vegetable oils have a viscosity between about 2 and about 15 cSt at 100°C, and less than about 110 cSt at 40°C.

acrylate. (1) Any of several monomers used for the manufacture of thermosetting acrylic surface coating resins, e.g., 2-hydroxyethyl acrylate (HEA) and hydroxypropyl acrylate (HPA). (2) Polymer of acrylic acid or its esters, used in surface coatings, emulsion paints, paper and leather finishes, etc.
See acrylic acid; acrylic resin.

acrylic acid. (acroleic acid; propenoic acid).
CAS: 79-10-7. $H_2C{:}CHCOOH$.



Properties: Colorless liquid; acrid odor. Bp 140.9C, mp 12.1C, d 1.052 (20/20C), vap press 3.1 mm (20C), bulk d 8.6 lb/gal (20C), refr index 1.4224 (20C). Flash p 130F (54.5C) (OC). Polymerizes readily. Miscible with water, alcohol, and ether. Combustible.
Derivation: (1) Condensation of ethylene oxide with hydrocyanic acid followed by reaction with sulfuric acid at 320F; (2) acetylene, carbon monoxide, and water, with nickel catalyst; (3) propylene is vapor oxidized to acrolein, which is oxidized to acrylic acid at 300C with molybdenum-vanadium catalyst; (4) hydrolysis of acrylonitrile.
Grade: Technical (esterification and polymerization grades), glacial (97%).
Hazard: Irritant and corrosive to skin. Toxic by inhalation. May polymerize explosively. TLV: 2 ppm in air.
Use: Monomer for polyacrylic and polymethacrylic acids and other acrylic polymers.
See acrylic resin.

acrylic fiber. A manufactured fiber in which the fiber-forming substance is any long-chain synthetic polymer composed of at least 85% (by weight) acrylonitrile units $-CH_2CH(CN)-$ (U.S. Federal Trade Commission).
Properties: Tensile strength 2–3 g/denier, water absorption 1.5–2.5%, d approx 1.17. Combustible.
Hazard: Fumes are toxic.
Use: Modacrylic fibers; blankets; carpets.
See modacrylic fiber; acrylic resin.

acrylic polymers. See acrylic resin.

acrylic resin. (acrylic fiber; nitrile rubber).
Thermoplastic polymers or copolymers of acrylic acid, methacrylic acid, esters of these acids, or acrylonitrile. The monomers are colorless liquids that polymerize readily in the presence of light, heat, or catalysts such as benzoyl peroxide; they must be stored or shipped with inhibitors present to avoid spontaneous and explosive polymerization.
Properties: Acrylic resins vary from hard, brittle solids to fibrous, elastomeric structures to viscous liquids, depending on the monomer used and the method of polymerization. A distinctive property of cast sheet and extruded rods of acrylic resin is ability to transmit light.
Use: Bulk-polymerized: hard, shatterproof, transparent or colored material (glass substitute, decorative illuminated signs, contact lenses, dentures, medical instruments, specimen preservation, furniture components). Suspension-polymerized: beads and molding powders (headlight lenses, adsorbents in chromatography, ion-exchange resins). Solution polymers: coatings for paper, textiles, wood, etc. Aqueous emulsions: adhesives, laminated structures, fabric coatings, nonwoven fabrics. Compounded prepolymers: exterior auto paints, applied by spray and baked. Acrylonitrile-derived acrylics are extruded into synthetic fibers and are also the basis of the nitrile family of synthetic elastomers.
See acrylic acid; acrylonitrile; methyl methacrylate.

"Acryloid" coating resins ***[Rohm & Haas].***
TM for acrylic ester polymers in organic solvent solutions or 100% solid forms; water-white and transparent. Films range from very hard to very soft.
Use: Exceptionally resistant surface coatings, such as heat-resistant and fumeproof enamels; vinyl and plastic printing; fluorescent coatings; clear and pigmented coatings on metals.

"Acryloid" Modifiers ***[Rohm & Haas].*** TM for thermoplastic acrylic polymers in powder form. Various grades facilitate processing or improve physical properties of rigid or semi-rigid polyvinyl chloride formulations.

"Acryloid" oil additives ***[Rohm & Haas].***
TM for acrylic polymers supplied in special oil solution or in diester lubricant.
Use: Viscosity-index improvement, pour-point depression of lubricating oils and hydraulic fluids, sludge dispersancy in lubricating and fuel oils.

"Acrylon" ***[Borden].*** TM for a group of acrylic rubbers outstanding in resistance to oil, grease, ozone, and oxidation.
Use: Gaskets and rubber parts for contact with oils and diester lubricants.

acrylonitrile. (propenenitrile; vinyl cyanide).
CAS: 107-13-1. $H_2C{:}CHCN$.
40th highest-volume chemical produced in U.S. (1995).
Properties: Colorless, mobile liquid; mild odor. Fp −83C; bp 77.3–77.4C, d 0.8004 (25C), flash p 32F (0C) (TOC). Soluble in all common organic solvents; partially miscible with water.
Derivation: (1) From propylene oxygen and ammonia with either bismuth phosphomolybdate or a uranium-based compound as catalysts; (2) addition of hydrogen cyanide to acetylene with cuprous chloride catalyst; (3) dehydration of ethylene cyanohydrin.

hydroboration. The reaction of diboranes either with alkenes (olefins) to form trialkylboron compounds or with acetylene to yield alkenylboranes. Much research has been devoted to developing these reactions, the products of which are called organoboranes. They are useful in many complex organic syntheses, including prostaglandins and insect pheromones.
See borane; organoborane; carborane.

hydrobromic acid.
CAS: 10035-10-6. Hydrogen bromide in aqueous solution.
Properties: Colorless or faintly yellow liquid consisting of an aqueous solution of hydrogen bromide, which is a gas at room temperature. Soluble in water and alcohol, a constant-boiling solution is formed of d 1.49, containing 48% hydrogen bromide; bp at 700 mm Hg (122C), saturated solution contains 68.8% hydrogen bromide at 0C. Hydrobromic acid is a strong acid and sensitive to light. Noncombustible.
Derivation: By dissolving hydrogen bromide in water or by distilling from a mixture of sodium bromide and 50% sulfuric acid.
Grade: Technical 40%; medicinal 48%, 62%.
Hazard: Strong irritant to eyes and skin.
Use: Analytical chemistry, solvent for ore minerals, manufacture of inorganic and some alkyl bromides, alkylation catalyst.
See hydrogen bromide.

hydrocarbon. An organic compound consisting exclusively of the elements carbon and hydrogen. Derived principally from petroleum, coal tar, and plant sources. Following is a list of the principal types.

I. Aliphatic (straight chain)
 (1) Paraffins (alkanes): generic formula C_nH_{2n+2}. Saturated (single bonds only).
 (2) Olefins: generic formula C_nH_{2n}.
  (a) Alkenes: unsaturated (one double bond).
  (b) Alkadienes: unsaturated (two double bonds) (butadiene).
 (3) Acetylenes: generic formula C_nH_{2n-2}. Unsaturated (triple bond).
 (4) Acyclic terpenes. Unsaturated (polymers of isoprene, C_5H_8).

Note: Some aliphatic compounds have branched chains in which the subchain also contains carbon atoms (isobutane); both chains are essentially straight.

II. Cyclic (closed ring)
 (1) Alicyclic: three or more carbon atoms in a ring structure with properties similar to those of aliphatics.
  (a) Cycloparaffins (naphthenes): saturated compounds often having a boat or chair structure, e.g., cyclohexane, cyclopentane.
  (b) Cycloolefins: unsaturated (two or more double bonds), e.g., cyclopentadiene (2), cyclooctatetraene (4).
  (c) Cycloacetylenes (cyclynes): unsaturated (triple bond).
 (2) Aromatic: unsaturated, hexagonal ring structure (three double bonds), single rings and double or triple fused rings.
  (a) Benzene group (1 ring).
  (b) Naphthalene group (2 rings).
  (c) Anthracene group (3 rings).
 (3) Cyclic terpenes: monocyclic (dipentene); dicyclic (pinene).

Note: Olefinic (isoprenoid) hydrocarbons are produced by a number of plants, notably *Hevea braziliensis* (rubber), guayule, and various members of the Euphorbiaceae family. Current research on the latter group indicates that they could be used as a source of liquid fuels and chemical feedstocks by genetic modification of the plants and control of their molecular constitution. It is estimated that oil obtained by large-scale cultivation of such plants, which grow well in semiarid environments, could become economically competitive with petroleum within a few years.
See guayule; biomass; copaiba.

hydrocarbon gas streams. A hydrocarbon such as methane is contacted with a catalyst under moderate conditions of temperature and pressure and decomposed into carbon, which remains on the catalyst, and hydrogen, which is mechanically removed. The hydrogen produced is about 94% pure when the charge stock is methane.

hydrocarbon, halogenated. A hydrocarbon in which one or more of the hydrogen atoms has been replaced by fluorine, chlorine, bromine, or iodine. Examples: carbon tetrachloride, chlorobenzene, chloroform, trifluoromethane. This greatly increases the anesthetic and narcotic action of aliphatic hydrocarbons. Many halogenated hydrocarbons are highly toxic; some may detonate on contact with barium. A number of the chlorinated types are used as insecticides.
See fluorocarbon; chlorofluorocarbon.

hydrocellulose. See cellulose, hydrated.

hydrochloric acid. (HCl).
CAS: 7647-01-0. 27th-highest-volume chemical produced in U.S. (1995). Hydrogen chloride in aqueous solution.
Properties: Colorless or slightly yellow, fuming, pungent liquid. Flash p none. A constant-boiling acid containing 20% hydrochloric acid is formed. Hydrochloric acid is a strong, highly corrosive acid. The commercial "concentrated" or fuming acid contains 38% hydrochloric acid and has a d 1.19. Soluble in water, alcohol, and benzene. Noncombustible.

TEMPERATURE CORRECTION FOR GLASS VOLUMETRIC APPARATUS

This table gives the correction to be added to actual capacity (determined at certain temperatures) to give the capacity at the standard temperature, 20°C. Conversely, by subtracting the corrections from the indicated capacity of an instrument standard at 20°C, the corresponding capacity at other temperatures is obtained. The table assumes for the cubical coefficient of expansion of glass 0.000025 per degree centigrade. The coefficients of expansion of glasses used for volumetric instruments vary from 0.000023 to 0.000028.

Temperature in degrees C.	2,000 ml	1,000 ml	500 ml	400 ml	300 ml	250 ml
15	+0.25	+0.12	+0.06	+0.05	+0.04	+0.031
16	+ .20	+ .10	+ .05	+0.04	+ .03	+ .025
17	+ .15	+ .08	+ .04	+ .03	+ .02	+ .019
18	+ .10	+ .05	+ .02	+ .02	+ .02	+ .012
19	+ .05	+ .02	+ .01	+ .01	+ .01	+ .006
21	− .05	− .02	− .01	− .01	− .01	− .006
22	− .10	− .05	− .02	− .02	− .02	− .012
23	− .15	− .08	− .04	− .03	− .02	− [illegible]
24	− .20	− .10	− .05	− .04	− .03	− [illegible]
25	− .25	− .12	− .06	− .05	− .04	− [illegible]
26	− .30	− .15	− .08	− .06	− .04	− [illegible]
27	− .35	− .18	− .09	− .07	− .05	− [illegible]
28	− .40	− .20	− .10	− .08	− .06	− [illegible]
29	− .45	− .22	− .11	− .09	− .07	− [illegible]
30	− .50	− .25	− .12	− .10	− .08	− [illegible]

DENSITY OF VARIOUS LIQUIDS

(Selected from Smithsonian Tables.)

Liquid	Grams per cu. cm	Pounds per cu. ft.	Temp °C
Acetone	0.792	49.4	20°
Alcohol, ethyl	0.791	49.4	20
methyl	0.810	50.5	0
Benzene	0.899	56.1	0
Carbolic acid	0.950–0.965	59.2–60.2	15
Carbon disulfide	1.293	80.7	0
tetrachloride	1.595	99.6	20
Chloroform	1.489	93.0	20
Ether	0.736	45.9	0
Gasoline	0.66–0.69	41.0–43.0	
Glycerin	1.260	78.6	0
Kerosene	0.82	51.2	
Mercury	13.6	849.0	

Liquid	Grams per cu. cm	Pounds per cu. ft.
Milk	1.028–1.035	64.2–64.6
Naphtha, petroleum ether	0.665	41.5
wood	0.848–0.810	52.9–50.[illegible]
Oils:		
castor	0.969	60.5
coconut	0.925	57.7
cotton seed	0.926	57.8
creosote	1.040–1.100	64.9–[illegible]
linseed, boiled	0.942	58.8
olive	0.918	57.3
Sea water	1.025	63.99
Turpentine (spirits)	0.87	54.3
Water	1.00	62.4[illegible]

DENSITY OF ALCOHOL

DENSITY OF ETHYL ALCOHOL IN GRAMS PER CUBIC CENTIMETER, COMPUTED FROM MENDELEEFF'S FORMULA.

(Selected from Smithsonian Tables.)

Temp. °C	0	1	2	3	4	5	6	7	8
0	.80625	.80541	.80457	.80374	.80290	.80207	.80123	.80039	.79956
10	.79788	.79704	.79620	.79535	.79451	.79367	.79283	.79198	.79114
20	.78945	.78860	.78775	.78691	.78606	.78522	.78437	.78352	.78267
30	.78097	.78012	.77927	.77841	.77756	.77671	.77585	.77500	.77414

HYDROMETERS AND DENSITY UNITS

Alcoholometer. — For testing alcoholic solutions: the scale shows the per cent of alcohol by volume; 0°–100° is the per cent.

Ammoniameter. — For testing ammonia solutions; scale 0°–40°; to convert to sp. gr. multiply by 3 and deduct from 1000.

Barktrometer or *Barkometer.* — For testing tanning liquor; scale 0°–80° Bk; the number to the right of the decimal point of the sp. gr. is the degree Bk; thus, 1.025 sp. gr. is 25° Bk.

Baumé. — There are two kinds in use; heavy Bé, for liquids heavier than water and light Bé for liquids lighter than water. In the former, 0° corresponds to a sp. gr. 1.000 (water at 4°C.) and 66° corresponds to a sp. gr. 1.842; in the lighter than water scale, 0° Bé is equivalent to the gravity of a 10% solution of sodium chloride and 60° Bé corresponds to a sp. gr. of 0.745. For Baumé degrees on the scale of densities greater than unity, the following equation gives the means of conversion:

$$\text{Sp. gr.} = \frac{m}{m - d}$$

where m = 145 (in the United States)
m = 144 (old scale used in Holland)
m = 146.78 (New scale or Gerlach scale)
d = Baumé reading

Beck's Hydrometer has 0° corresponding to sp. gr. 1.000 and 30° to sp. gr. 0.850; equal divisions on the scale are continued as far as required in both directions.

Brix Saccharometer or *Balling Saccharometer* shows directly the per cent of sugar (sucrose) by weight at the temperature indicated on the instrument, usually 17.5°C.; i.e., degrees Brix is the per cent sugar.

Cartier's Hydrometer floats in water at the 10° scale division and at 30° corresponds to 32° Bé.

Oleometer.—For vegetable and sperm oils; scale 50°–0° corresponds to sp. gr. 0.870–0.970.

Soxhlet's Lactometer, for determining the density of milk, has a scale from 25° (sp. gr. 1.025) to 35° (sp. gr. 1.035) divided into suitable scale divisions.

Twaddell Hydrometers have the scale so arranged that the reading multiplied by 5 and added to 1000 gives the sp. gr. with reference to water as 1000; it is always used for densities greater than water.

HYDROMETER CONVERSION [illegible]

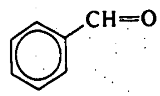
SHOWING THE RELATION BETWEEN DENSITY AND DEGREES BAUMÉ FOR DENSITIES L[illegible]

Density.	Degrees Baumé .00	.01	.02
0.60	108.33	99.51	95.81
.70	70.00	67.18	64.44
.80	45.00	42.84	40.73
.90	25.56	23.85	22.17
1.00	10.00	.....	.....

Density.	Degrees Baumé .05	.06	.07
0.60	85.38	82.12	78.[illegible]
.70	56.67	54.21	51.[illegible]
.80	34.71	32.79	30.[illegible]
.90	17.37	15.83	14.[illegible]
1.00	......	.....	.....

Liquid	Temp. °C	Viscosity cp
Methyl amine	0	.236
aniline	25	2.02
	30	1.55
chloride	20	.1834
Methylene bromide	15	1.09
	30	0.92
chloride	15	.449
	30	.393
Methyl iodide	0	.606
	15	.518
	20	.500
	30	.460
	40	.424
Naphthalene	80	.967
	100	.776
Nitric acid	0	2.275
	10	1.770
Nitrobenzene	2.95	2.91
	5.69	2.71
	5.94	2.71
	9.92	2.48
	14.94	2.24
	20.00	2.03
Nitromethane	0	.853
	25	.620
o-Nitrotoluene	0	3.83
	20	2.37
	40	1.63
	60	1.21
m-Nitrotoluene	20	2.33
	40	1.60
	60	1.18
p-Nitrotoluene	60	1.20
n-Nonane	20	.711
n-Octane	0	.706
	16	.574
	20	.542
	40	.433
Octodecane	40	2.86
n-Octylalcohol	15	10.6
Oil, castor	10	2,420
	20	986
	30	451
	40	231
	100	16.9
cottonseed	20	70.4
cylinder, filtered	37.8	240.6
	100	18.7
cylinder, dark	37.8	422.4
	100	24.0
linseed	30	33.1
	50	17.6
	90	7.1
machine, light	15.6	113.8
	37.8	34.2
	100	4.9
machine, heavy	15.6	660.6
	37.8	127.4
Oil, olive	10	138.0
	20	84.0
	40	36.3
	70	12.4
rape	0	2,530
	10	385
	20	163
	30	96
soya bean	20	69.3
	30	40.6
	50	20.6
	90	7.8
sperm	15.6	42.0
	37.8	18.5
	100.0	4.6
Oleic acid	30	25.6
Pentadecane	22	2.81
Pentane	0	.289
	20	.240
o-Phenetidine	0	16.5
	20	6.08
	30	4.22
m-Phenetidine	30	12.9
p-Phenetidine	20	12.9
	30	8.3
Phenol	18.3	12.7
	50	3.49
	60	2.61
	70	2.03
	90	1.26
Phenylcyanide	.28	1.96
	20.0	1.33
Phosphorus, liq	21.5	2.34
	31.2	2.01
	43.2	1.73
	50.5	1.60
	60.2	1.45
	69.7	1.32
	79.9	1.21
Potassium bromide, liq	745	1.48
	775	1.34
	805	1.19
nitrate, liq	334	2.1
	358	1.7
	333	2.97
	418	2.00
Propionic acid	10	1.289
	15	1.18
	20	1.102
	40	.845
Propyl acetate	10	.66
	20	.59
	40	.44
n-Propyl alcohol	0	3.883
	15	2.52
	20	2.256
	30	1.72
	40	1.405

benzaldehyde. (benzoic aldehyde; synthetic oil of bitter almond).
CAS: 100-52-7. C_6H_5CHO.



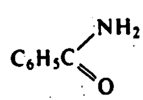
Properties: Colorless or yellowish, strongly refractive, volatile oil; odor resembling oil of bitter almond; burning aromatic taste. Oxidizes readily. D 1.0415 (25/4C), refr index 1.5440–1.5464 at 20C, fp −56C; bp 178C, flash p 145F (62.7C) (CC). Miscible with alcohol, ether, fixed and volatile oils; slightly soluble in water. Oxidizes in air to benzoic acid. Combustible. Autoign temp 377F (191.6C).
Derivation: (1) Air oxidation of toluene with uranium or molybdenum oxides as catalysts; (2) reaction of benzyl dichloride with lime; (3) extraction from oil of bitter almond.
Impurities: Usually chlorides.
Method of purification: Rectification.
Grade: Technical, NF. *Note:* The specifications, especially regarding impurities, vary considerably for the grades used for dye manufacture from those used in perfumery.
Hazard: Highly toxic.
Use: Chemical intermediate for dyes, flavoring materials, perfumes, and aromatic alcohols; solvent for oils, resins, some cellulose ethers, cellulose acetate and nitrate; flavoring compounds; synthetic perfumes; manufacturing of cinnamic acid, benzoic acid; pharmaceuticals; photographic chemicals.

benzaldehyde cyanohydrin. See mandelonitrile.

benzaldehyde green. See Malachite green.

benzalkonium chloride. A mixture of alkyl dimethylbenzylammonium chlorides of general formula $C_6H_5CH_2N(CH_3)_2RCl$ in which R is a mixture of the alkyls from C_8H_{17} to $C_{18}H_{37}$. It is a typical quaternary ammonium salt.
Properties: White or yellowish-white, amorphous powder or gelatinous pieces; aromatic odor; very bitter taste. Soluble in water, alcohol, or acetone; almost insoluble in ether; slightly soluble in benzene. Water solutions foam strongly when shaken and are alkaline to litmus.
Grade: USP.
Hazard: Highly toxic.
Use: Cationic detergent; surface antiseptic; fungicide.

benzamide. (benzoylamide). $C_6H_5CONH_2$.



Properties: Colorless crystals. Mp 130C, bp 288C, d 1.341. Soluble in hot water, hot benzene, alcohol, and ether. Combustible.
Derivation: From benzoyl chloride and ammonia or ammonium carbonate.
Grade: Technical.
Use: Organic synthesis.

benzaminoacetic acid. See hippuric acid.

benzanilide. (benzoylaniline; phenylbenzamide). $C_6H_5NH(COC_6H_5)$.
Properties: White to reddish crystals and powder. Related to acetanilide, containing benzoyl in place of acetyl radical. D 1.306, mp 160–162C. Soluble in alcohol; insoluble in water; slightly soluble in ether.
Derivation: From benzoic anhydride and aniline with sodium hydroxide.
Use: Intermediate in the synthesis of dyes, drugs, and perfumes.

benzanthrone. $C_{17}H_{10}O$. A four-ring system.
Properties: Pale-yellow needles. Mp 170C. Soluble in alcohol and other organic solvents.
Derivation: (1) From anthranol and glycerol via condensation via sulfuric acid (anthranol is made from anthraquinone), (2) from anthracene in sulfuric acid solution by addition of glycerol and heating to 100–110C until the anthracene disappears. The reaction mass is then diluted with water, salted out, and purified.
Method of purification: Crystallization from toluene.
Use: Dyes.

benzathine penicillin G. (*N,N'*-dibenzylethylenediamine dipenicillin G).
$2C_{16}H_{18}N_2O_4S{\cdot}C_{16}H_{20}N_2{\cdot}4H_2O$.
Properties: White crystalline powder; odorless. The pH of a saturated solution is 4.5–7.5. Slightly soluble in alcohol; almost insoluble in water.
Grade: USP.
Use: Medicine (antibiotic).

benzazimide. See 4-ketobenzotriazine.

"Benzedrine" ***[SmithKline].*** TM for amphetamine sulfate.

benzene.
CAS: 71-43-2. C_6H_6. 16th highest-volume chemical produced in U.S. (1995).